# UPPER CAPE COD
# CANCER INCIDENCE REVIEW

1986-1994
Volume I of II

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH
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TABLE OF CONTENTS

**VOLUME I**

# I. INTRODUCTION

The purpose of this report is to present cancer incidence data for Upper Cape Cod by census tract for the period 1986 to 1994. Descriptive statistics for Upper Cape Cod towns and census tracts have previously indicated that the incidence of some types of cancer has been significantly greater than expected for the 1982-1990 period.[1, 2]

In 1991, under contract to the Massachusetts Department of Public Health (MDPH), Aschengrau[1] of Boston University conducted a case-control study of hypotheses concerning possible associations between contamination from the Massachusetts Military Reservation (MMR) (see the Otis/Camp Edwards Health Assessment prepared by the Agency for Toxic Substances and Disease Registry (ATSDR) for background on the environmental contamination[3] ) and other sources on Upper Cape Cod and the incidence of nine specific types of cancer (i.e., leukemia and cancers of the lung, breast, colo-rectal, bladder, kidney, pancreas, brain and liver). At that time, potential environmental exposures from contaminants originating from the MMR or other known sources (e.g., cranberry bogs, local ponds, public water supplies, and the Canal Electric plant), were not associated, according to the investigator, with much of the elevation in the Upper Cape's cancer rates.

The above-stated conclusions were drawn from an analytic study in which information on residential history and non-environmental risk factors for cancer was collected from individual participants -- a design that is superior to that of studies evaluating cancer rates, because of its ability for detecting associations between health outcomes and suspected risk factors.[5] Nevertheless, concern remains that an association between cancer and some unknown or inadequately measured environmental exposures has gone undetected. Legislators and community representatives have responded to this concern by requesting further study.

In 1995, the Bureau of Environmental Health Assessment (BEHA) completed an examination of cancer incidence by census tract for the period 1982 to 1990 as a means of exploring geographic patterns of cancer rates.[2] Cancer incidence on Upper Cape Cod was found to have a varied geographic distribution and followed no single pattern. Breast, colon-rectal, lung and prostate cancers occurred at elevated rates in most Upper Cape Cod census tracts. Breast cancer incidence was elevated in tracts from three widely separated geographic areas 1) most Barnstable tracts, 2) tracts along Nantucket Sound in Falmouth, and 3) all tracts in Bourne (including the MMR). Other types of cancer most commonly elevated were malignant melanoma and cancer of the urinary bladder. Rates of three less common cancer types, brain/CNS, cervix and larynx were found to be elevated in tracts near or abutting the MMR.

To further examine the geographic distribution of cancer incidence, the MDPH has updated the 1982 - 1990 cancer incidence data with the four most recently available years of data from the Massachusetts Cancer Registry (MCR). The data presented in this report represent the occurrence of cancers diagnosed among Upper Cape residents between the years 1986 and 1994. The purpose of this update is to continue surveillance of cancer on Upper Cape Cod in an attempt to generate hypotheses that could be tested in more comprehensive environmental epidemiological studies.

Comments on the draft of this report were received from members of the ATSDR's Community Assistance Panel (CAP) and the CAP's technical advisors last year. The major comments received included a request for maps depicting the incidence figures, inclusion of town-level incidence data, comparison of data presented in this report with data presented in MCR reports, and a discussion of the possible effect on the calculation of SIRs of validating addresses. In addition, since the MCR reports exclude *in situ* (localized) carcinomas, some of the figures on expected numbers of cancers in this report were adjusted in order to include only invasive cancers. Only recently has the MCR made *in situ* data available to researchers and only for cases diagnosed since 1992. The adjustment affected only state rates used to estimate expected numbers and involved primarily five types of cancer; bladder, breast, cervical, colon/rectum, and melanoma (and, consequently, total cancer). There was no change to any of the observed numbers of Upper Cape cancers and only slight changes to the SIRs for the above cancer types.

# II. METHODS

## A. Study Population

The study population for this statistical review included all individuals who were residing in the Massachusetts towns of Barnstable, Bourne, Falmouth, Mashpee, and Sandwich between January 1986 and December 1994. In this report these five towns are collectively referred to as Upper Cape Cod (see Figure 1). The time period 1986 to 1994 was chosen in response to citizen concerns about including the most recently available incidence data and choosing a time period with 1990 as the mid-point. The most recent population data from United States Census is available for the year 1990.

## B. General Approach

In order to identify geographic patterns of cancer incidence, standardized incidence ratios (SIRs) and 95 % confidence intervals (95% CI) were calculated by cancer type and sex for each of the 30 census tracts that comprise Upper Cape Cod. As a result, up to 2,250 SIRs could be calculated -- one for each combination of 30 Upper Cape Cod census tracts, 25 cancer types, and three sex categories (i.e., males, females, males and females combined).

## C. Assignment of Observed Cases to Census Tracts

### 1. Case Identification

The observed numbers of cases were derived from 6,244 primary site cancer cases diagnosed between 1986 and 1994 among residents of the five Upper Cape Cod towns, as reported to the Massachusetts Cancer Registry (MCR) by February 1997.

Cancer cases were selected for inclusion based on the reported home address, not the address of the diagnosing hospital. Massachusetts residents diagnosed at out of state hospitals were also included in the data set because of the MCR's reciprocal reporting agreements with states where Massachusetts residents may be diagnosed (i.e., Connecticut, Florida, Maine, New Hampshire, New York, and Rhode Island).

The MCR began collecting cancer incidence data in 1982. All newly diagnosed cancer cases are required to be reported to the MCR within six months of the date of diagnosis. It is estimated that the MCR files contain data on 90-95 % of all reportable cases -- a level comparable to that achieved by other state cancer registries.

MCR records provide limited information on each reported case. Each record contains the case's street address, age at diagnosis, sex, primary cancer site, histological subtype, and diagnosis date, as well as information on usual occupation and smoking history.

### 2. Determination of Cancer Type

Cancer type was determined from the primary and histology codes used by the MCR to classify cancer cases. The coding system follows the International Classification of Diseases for Oncology (ICD-O) system.[7, 8] The 25 groupings (see Table 1) used in this review correspond exactly to those used by the MCR and the National Cancer Institute's Surveillance, Epidemiology, End Results (SEER) program. Included among the groupings are 23 individual cancer types, one category of rare or difficult-to-classify malignancies, and one category for all cancers combined. Diagnoses of *in situ* carcinomas are excluded from this report.

The ICD-O coding system was updated in 1991, resulting in the 1986 to 1994 cancer data being reported to the MCR under two different coding systems. At the time that the BEHA requested the Upper Cape cancer data, the MCR had not completed incorporating the ICD-O changes mentioned above into its mainframe computer program. NCSS 6.0 statistical software was used to categorize the cancer cases into a single system.

### 3. Creation of the Data File

A dBASE III computer file of all cancer cases was compiled for the study population from the main MCR data file. The dBASE file was then checked for duplicate reports of the same diagnosis. Duplicate reports of the same case diagnosis are occasionally made to the MCR as a result of individuals seeking

second opinions or follow-up treatment from different institutions. Most duplicates are eliminated by the MCR, but some are missed because of a misspelled name or address, incorrect birth date, or similar problem in the duplicate record. Suspected duplicate reports were verified with MCR staff before deletion from the dBASE file.

### 4. Determination of Census Tract of Residence

The census tract assignment protocol required that the location of each case's residential address be identified on a map showing the census tract boundaries. The dBASE file was loaded into a computerized mapping system called MapInfo to perform the mapping. Table 2 and Figure 1 provide a listing of the census tracts included in each of the five towns and the locations of their boundaries.

MapInfo used the address information for each case record in the dBASE file to map cases. In order for mapping to occur, the case's dBASE-listed address had to exist in MapInfo's address files. MapInfo was programmed to automatically map all dBASE-listed addresses for which an exact match could be found in the MapInfo address files. An exact match implied that the five separate components of the two addresses were identical: 1) town, 2) house number, 3) prefix direction (i.e., North in North Main Street, 4) street name, and 5) street type (e.g., street, road, or avenue). When an exact match for a dBASE-listed address could not be found, MapInfo was prompted for a list of addresses that matched the case's address closely but not exactly. It was very common for these addresses to match the dBASE-listed address in every respect except the street type (e.g., dBASE-listed address is 25 Pine Road, Barnstable; MapInfo lists a 25 Pine Street in Barnstable but no Pine Road at all). If other sources (e.g., street lists, atlases) agreed that there was no street of the name and type listed in the dBASE file, these close matches were assumed to be exact matches, and MapInfo was allowed to map its close-matching address as the case's address. Also common were instances where MapInfo listed an address that matched a dBASE-listed address exactly except for some small spelling difference that clearly signified a spelling error in the dBASE file (e.g., dBASE-listed address = 13 Wincester Street, Barnstable; MapInfo lists a 13 Winchester Street, Barnstable). Such close matches were also assumed to be exact matches, and MapInfo was allowed to map its close-matching address as the case's address.

Some Upper Cape Cod streets were found to be missing from the MapInfo database, and some valid house numbers were missing from MapInfo listed streets. To allow mapping, we located the missing streets on street atlases and added these locations to the MapInfo file. Town clerks, assessors, and engineers were also consulted about the location of public and private streets that did not appear in the MapInfo files.

In addition to consulting these sources, the latitude and longitude coordinates for a portion of the missing addresses were obtained using a satellite tracking positioning system. The Trimble Geo-Explorer Global Positioning System (GPS) and associated GEO-PC software were borrowed from the MassGIS and the Executive Office of Environmental Affairs. Staff traveling to each residence and triangulating the position of the address between three satellites measured the latitude and longitude coordinates. Corrections were made for satellite height, speed and signal strength using the University of Rhode Island base station files, the geographically closest base station available. At least 120 measurements were taken at each address. After correction with the base station files, the average latitude and longitude coordinates were calculated from these 120 measurements and entered into the data file.

For some cases, the dBASE-listed address was a mailing address (i.e., post office box or RFD number) or was an incomplete address (i.e., no house number or a lot number). For cases diagnosed between 1986 and 1990, the dBASE file used in the 1995 Upper Cape Cancer Incidence Review was examined for address corrections. If no address correction was available or if the case was diagnosed after 1990, telephone books, annual town censuses, town assessors' maps and legal activities recorded in the Barnstable Country Registry of Deeds were used in combination to obtain a street address for these cases. Name, age, partial address, and town of residence were used to identify cases in these data sources. Because a case may move during the years following diagnosis, addresses were only accepted from sources that had residential address information that had been compiled within two years of the case's diagnosis date. If the only available residential address information came from a source(s) compiled more than two years after the diagnosis date, the case was not mapped.

The steps followed in the assignment of cases to census tracts are outlined in the flowchart that appears as Figure 2.

## D. The SIR Calculation

In order to evaluate whether cancer incidence is elevated, standardized incidence ratios (SIRs) are calculated. An SIR estimates the occurrence of disease in a population relative to what might be expected if the population had the same cancer experience as some larger population designated as "normal" or average.[3] Usually, the state as a whole is selected to be the "normal" population. SIRs were not calculated when fewer than five cases were observed in a census tract because the resulting SIRs are statistically unstable due to large fluctuations that can occur from the addition or subtraction of only one expected or observed cancer.

Specifically, an SIR is the ratio of the observed number of cancer cases to the expected number of cases. An SIR of 100 indicates that the number of cancer cases observed in the population being evaluated is equal to the number of cancer cases expected in the normal population. An SIR greater than 100 indicates that more cancer cases occurred than expected; an SIR less than 100 indicates that fewer cancer cases occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more cases than the expected number; an SIR of 90 indicates 10% fewer cases than expected. Caution should be exercised, however, when interpreting an SIR.

The interpretation of an SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on two expected cases and three observed cases indicates a 50% excess in cancer, but the excess is actually only one case. Conversely, an SIR of 150 based on two hundred expected cases and three hundred observed cases represents the same 50% excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is less likely that the 100 excess cases of cancer would occur by chance alone than the single excess case.

### 1. Confidence Interval Estimation

To determine if the observed number of cases is statistically significantly different from the expected number or if the difference may be due solely to chance, a 95% confidence interval (95% CI) is calculated. A 95% CI represents the range of estimated SIR values that have a 95% probability of including the true SIR for the population. If the confidence interval range does not include the value 100, then the study population is statistically significantly different from the "normal" population. A "statistically significant difference" means there is less than 5 percent chance that the observed difference is merely the result of random fluctuation in the number of observed cancer cases. For example, if a confidence interval does not include 100 and the interval is above 100, then there is a significant excess in the number of cancer case. Similarly, if the confidence interval does not include 100 and the interval is below 100, then the number of cancer cases is significantly lower than expected. If the confidence interval range includes 100, the true SIR may be 100, and it cannot be concluded with sufficient confidence that the observed number of cases reflects a real cancer excess or deficit.

In addition to the number of cases, the width of the confidence interval also reflects the stability or precision of the SIR estimate. For example, a narrow confidence interval (e.g., 103 to 115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85 to 450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic.

Ninety-five percent confidence intervals for the SIRs were calculated by the following formula, which assumes a Poisson distribution for the observed frequency of cases:

Lower Limit = $a(1 - 1/9a - (z/3)(1/a)^{1/2})^3/b$

$$\text{Upper Limit} = (a + 1)\left(1 - 1/(9(a+1)) + (z/3)(1/(a+1))^{1/2}\right)^3/b$$

where a is the observed number of cases, b is the expected number of cases, and z represents the standard normal deviate corresponding to a 95% confidence level.[1]

### 2. Calculation of Expected Number of Cases

The number of cancer cases expected to occur among the residents of a specific census tract in a given age/sex category was obtained by multiplying the state rate for the category times the number of census-tract residents in that category (as reported by the 1990 U. S. Census). For example, 313 men between the ages of 65 and 74 were residing in census tract 126 in Barnstable during 1990. The state prostate cancer rate for the period 1986-1994 was 7.9 cases per 1,000 men. We would expect 22.4 cases of prostate cancer to have occurred in census tract 126 during this period (7.9/1,000 X 313 men age 65-74 in 1990 X 9 years) if prostate cancer was occurring in census tract 126 at the state background rate. Table 7 provides an example of the age adjustment procedure used to calculate the expected number of cancers.

The total number of cases of a given cancer type expected in a census tract over a particular time period was obtained by adding the expected numbers of cases across all ten age groups. Expected numbers were generated separately for males and females (for cancers that occur in both sexes).

### 3. Age-Specific Population Data by Census Tract

The population in each age and sex category for the state and for each of the 30 census tracts was needed to estimate the expected number of cases. The 1990 census population, taken from the Modified Age, Race, Sex (MARS) file, was chosen since it was the midpoint of the 1986 to 1994 time period. Appendix A presents a summary of the 1990 age and sex specific population values for each census tract.

## E. Interpretation of Cancer Incidence Data

The primary focus of this review is to examine the pattern of elevations in cancer incidence. Three guidelines are used to determine whether the incidence of a cancer type in a particular census tract or town may be elevated. These guidelines are based on a conservative approach to evaluating elevations in cancer incidence, based not solely on the size of the SIR or on statistical significance, that also allows us to search for elevations in census tracts where an SIR cannot be calculated. This conservative, although non-traditional, approach is necessitated by the small sample sizes that are available for analysis of some cancer types.

The first guideline reflects a more traditional use of statistics, where SIRs that are larger than 100 and whose confidence intervals do not include 100 (i.e., statistically significant), are considered definitive estimates of whether incidence is elevated or not. The difference between observed and expected numbers of cases for an SIR that reaches statistical significance is not likely due to chance.

At the census tract level of analysis however, sample size considerations may not allow an SIR to reach statistical significance. For this reason, the second guideline for identifying elevations considers SIRs with values of 115 or greater to be possible elevations, regardless of the range of their confidence interval. This arbitrarily set value is used to identify those census tracts with more observed than expected cases but for which the SIR estimates are too unstable to reliably rule out chance as the explanation for the elevation.

In addition, when doing analyses by census tract, many SIRs cannot be calculated because the number of observed cases is very small (i.e., less than 5 cases). In a small population, the observed number of cases would likely be very small because cancer is such a rare disease, even if there was a high incidence of cancer in the population. In this situation, it is extremely difficult to differentiate real differences between observed and expected numbers of cases from differences due to statistical fluctuations. The third guideline was developed for situations where an SIR cannot be calculated. When an SIR cannot be calculated and the observed number of cases is greater than the expected number by two or more cases, we have considered such instances possible elevations.

### F. Presentation of Results

Several tables and figures are included to provide detail to the reader regarding some aspects of the text. Figure 3a provides a series of maps, presenting the elevations for a particular cancer type by census tract for each sex. Figure 3b displays the size of the SIR for a particular cancer type by sex. These figures are in alphabetical order by cancer type and with separate tables for different sex categories. The tables containing the primary results are found in Appendices C and D. A few figures were not produced because of the small numbers of cases (e.g., female bladder cancer).

Appendix A presents summary population data for each census tract. Appendix B gives summary SIR values for each census tract, grouped by cancer type. Appendix C provides the observed and expected numbers of cases, SIRs, and 95% CI for each cancer type for Upper Cape Cod as a whole and for each town. The town level and Upper Cape Cod numbers are generated by summing observed and expected numbers of cancers across census tracts and then calculating SIRs and 95% CIs. Appendix D is the main body of results where the observed and expected numbers of cases, SIRs, and 95 % CIs are provided for each cancer type, grouped by census tract. Appendix E provides a series of sensitivity analyses that will be reviewed in the discussion section. All Appendices are located in Volume II.

## III. RESULTS

It is not possible to highlight all results that may be of interest, since a very large amount of data has been produced as part of the incidence review. Instead, those results that are most notable in terms of their potential contribution to the overall elevated cancer incidence on Upper Cape Cod are discussed.

### A. Success of Case Assignment to Census Tracts

The MCR listed 6,244 cancer cases diagnosed among Upper Cape Cod residents between 1986 and 1994. Table 5 shows how the number of mapped cases relates to the number originally listed by the Massachusetts Cancer Registry (MCR).

#### 1. Misclassified Cases

Comparison between the first two columns of Table 5 shows that less than one percent (n = 31) of the MCR listings for Upper Cape Cod were duplicate reports.

Seventeen (less than one percent) of the remaining 6,213 MCR-listed Upper Cape Cod cancer cases were not residents of an Upper Cape town at the time of diagnosis. Four cases were people who actually lived in Wareham but whose MCR-listed town of residence was Bourne. Twelve cases reported by the MCR as Barnstable residents actually lived in Yarmouth. One case attributed by the MCR to Sandwich actually resided in Harwich.

The remaining 38 misclassified cases (7 originally classified in Barnstable, 15 in Bourne, 9 in Falmouth, 4 in Mashpee, and 3 in Sandwich) were Upper Cape Cod cases attributed by the MCR to the wrong Upper Cape Cod town. Table 5 provides the net change in the number of cases for each town (see "Adjust. Between Towns" column). Tables 6, 7, and 8 provide the number of misclassifications by type of misclassification, cancer type, year of diagnosis, sex and town. The misclassified cases did not cluster by cancer type, sex or year, with two exceptions. All the duplicate reports were attributed by the MCR to Barnstable residents. The majority of non-Upper Cape resident cases had been attributed by the MCR to Bourne and Barnstable.

During the mapping process, BEHA staff discovered that some cancer cases attributed by the MCR to an Upper Cape Cod town were actually not residents of any of the Upper Cape towns. Some of the misclassified cases were non-Upper Cape residents who had a mailing address in an Upper Cape town, particularly in zip code areas that overlap the boundaries of an Upper Cape and a non-Upper Cape town. For example, a Yarmouth resident may have their mail delivered to them by the post office in the Barnstable village of Hyannis. Their mailing address includes the Hyannis zip code and town. A similar zip code overlap exists in the Buzzards Bay area of Bourne and the town of Wareham, resulting in some Wareham residents being attributed by the MCR as Bourne residents. The possibility that the MCR might have attributed some Bourne and Barnstable cases to Wareham or Yarmouth resulting in an underascertainment of Upper Cape cases was also explored. It was found that the western boundaries for Bourne census tracts 137 and 138 coincided with the western boundary of zip code 02532 and, therefore, the MCR should have correctly classified all Bourne residents. Under-ascertainment was also ruled out for residents of Barnstable census tracts 123-125.

The only instance where Barnstable residents could conceivably have been attributed by the MCR to Yarmouth was for the far eastern part of census tract 122. This area is covered by zip code 02675 (Yarmouthport post office), which is shared with Yarmouth tract 121.

**2. Proportion of Eligible Cases Mapped**

About 99% (n = 6,196) of the original MCR cases remained eligible after the exclusion of the duplicate records and cases who lived outside the Upper Cape at diagnosis. Computer assisted mapping was carried out on all eligible cases.

For approximately 59% of the 6,196 eligible cases, the case's address exactly matched an address in the MapInfo database. MapInfo automatically mapped these addresses. In addition, approximately 9% of cases were mapped after the correction of obvious errors in the MCR (dBASE) files. Obvious errors were corrected by prompting MapInfo for a close match and confirming this exclusiveness of this address with the street atlas and/or town map.

The remaining 1,971 cases required using other data sources to map the case's address. Approximately sixty-four percent (1,261) of the remainder were cases whose MCR-listed street addresses existed in the specified towns but were missing from the MapInfo address files. The other 36% (710) of cases were post office box and rural route addresses or were incomplete addresses. A total of 6,137 cases (about 99% of eligible cases) were eventually mapped after their addresses were located through external sources, including 152 GPS identified addresses. Fifty-nine cases (less than one percent of the eligible cases) could not be mapped.

The observed and expected numbers of cancers, SIRs and 95% CIs for Upper Cape Cod and each town are available in Appendix C. SIRs at the census tract level are available in Appendix B. Please refer to Appendix D for the observed and expected numbers of cancers, SIRs and 95% CIs at the census tract level.

## B. Cancer Incidence by Cancer Type for the Upper Cape as a Whole

The total number of cancers diagnosed on the Upper Cape as a whole between 1986 and 1994 was about eleven percent above the number that was expected for males and females combined. This elevation was statistically significant (SIR = 111; 95% CI = 108-113) (Appendix C).

Close to two-thirds (62%) of the cancers diagnosed during 1986 and 1994 were of one of four major types of cancer -- colon-rectal, breast, lung, and prostate. This proportion is slightly greater than that observed for the state as a whole, where these four cancers make up about 58% of all cancers. On the Upper Cape, prostate was the most common cancer type (1,001 cases, 16.3% of total cancer), followed by breast (940 cases, 15.3%), colo-rectal (918 cases, 15.0%), and lung (916 cases, 14.9%). For the state as a whole, breast (16.4%) is the most common type followed by lung (14.4%), colo-rectal (14.4%), and then prostate (12.5%).

On Upper Cape Cod as a whole, the rate of breast cancer was statistically significantly higher than expected (SIR = 110; 95% CI = 103-117). Colo-rectal cancer was statistically significantly elevated among males and females combined (SIR = 112; 95% CI = 105-120), as well as for males alone (SIR = 115; 95% CI = 105-125). Lung cancer was also statistically significantly elevated for males and females combined (SIR = 112; 95% CI = 105-120), although this elevation was due solely to higher incidence among females (SIR = 133; 95% CI = 121-147). An elevation was also observed for prostate cancer, which was statistically significant (SIR = 130; 95% CI = 122-139).

Almost half of the other cancers diagnosed on the Upper Cape were bladder cancer, kidney cancer, melanoma, cancer of the mouth and pharynx, non-Hodgkin's lymphoma, pancreatic cancer, and uterine cancer. Of these types, bladder cancer was the most common (224 cases), followed by non-Hodgkin's lymphoma (180 cases), melanoma (172 cases), cancer of the mouth and pharynx (149 cases), uterine cancer (146 cases), kidney and renal cancer (138 cases), and pancreatic cancer (128 cases). This pattern is similar to that observed for the state as a whole, except for melanoma. Melanoma diagnoses account for a greater proportion of total cancer on the Upper Cape than in the state as whole.

The incidence of bladder cancer (SIR = 102), non-Hodgkin's lymphoma (SIR = 95) and uterine cancer (SIR = 94) were not elevated on the Upper Cape. Pancreatic cancer was slightly elevated with an SIR of 112. Melanoma was statistically significantly elevated in males and females combined (SIR = 135, 172 observed cases, about 127 expected).

Of the remaining types of cancer, three were elevated for males and females combined, although the elevations did not reach statistical significance. These included Hodgkin's disease (SIR = 116, 43 observed cases, about 37 expected), testicular cancer (SIR = 122, 33 observed cases, 27 expected), and cervical cancer (SIR = 118, observed cases = 62, about 53 expected).

### C. Cancer Incidence by Census Tract for Males and Females Combined

The pattern of incidence varied, as expected, from census tract to census tract. Total cancer was statistically significantly elevated in nine of the thirty census tracts for males and females combined (tracts # 125, 137, 140, 144, 146, 147, 148, 151, and 152). One other tract (tract # 123) had a possible elevation (i.e., SIR of 115 or greater).

The four major types of cancer (i.e., breast, colo-rectal, lung, and prostate) accounted for most of the cancer in each tract. At the census tract level, the proportion of total cancers made up of the major cancers was 55 to 68 %, a value similar to that seen for the Upper Cape as a whole. Generally, elevations were observed in at least two of the major cancers.

For breast cancer, which primarily affects females (there were 5 male breast cancer cases), three tracts had a statistically significant elevation (tract # 127, 131 and 149). Possible elevations, where the SIR was 115 or greater but not statistically significant, were observed in ten tracts (tracts # 123, 125, 132, 133, 135, 136, 137, 146, 151, and 152).

For colo-rectal cancer among males and females combined, four tracts were statistically significantly elevated (tracts # 123, 146, 148, and 152). Twelve other tracts had possible elevations (tracts # 124, 125, 127, 128, 129, 130, 136, 137, 138, 140, 143, and 150).

Statistically significant elevations for lung cancer in males and females combined were observed in four tracts (tracts # 124, 126, 144, and 148). Nine other tracts had possible elevations where the SIR was 115 or greater but not statistically significant (tracts # 122, 125, 132, 135, 137, 139, 140, 145, and 150).

Prostate cancer, which affects only males, was statistically significantly elevated in nine tracts (tracts # 128, 135, 140, 143, 144, 145, 149, 151, and 152). Eleven tracts had possible elevations (tracts # 125, 127, 129, 130, 132, 134, 138, 146, 147, 148, and 150).

Elevations were also noted in some of the other cancer types, however, in most instances the elevations did not reach statistical significance. The cancer types that most frequently occurred at numbers that were greater than expected were:

- Melanoma -- statistically significantly elevated in three tracts (tracts # 125, 133 and 147), with possible elevations in fourteen other tracts (tracts # 122, 127, 128, 130, 132, 134, 135, 140, 143, 144, 145, 146, 148, and 149).

- Bladder cancer -- eleven tracts have possible elevations (tracts # 125, 130, 131, 133, 134, 136, 138, 144, 146, 151, and 152).

- Kidney cancer -- statistically significant elevation in tract #147. Ten tracts had possible elevations (tracts # 122, 129, 130, 134, 136, 137, 143, 146, 148, and 152).

- Pancreatic cancer -- one tract with a statistically significant elevation (tract # 145). Ten tracts had possible elevations (tracts # 122, 126, 132, 137, 138, 140, 143, 146, 148, and 151).

- Cancer of the mouth/pharynx -- no elevations were statistically significant in any tracts but possible elevations were observed in ten tracts (tracts # 122, 124, 131, 133, 134, 137, 139, 144, 145, and 149).

- Non-Hodgkin's lymphoma -- no statistically significant elevations, but nine tracts had possible elevations (tracts # 125, 135, 136, 137, 140, 143, 147, 148, and 150).

- Ovarian cancer (females only) -- statistically significant elevation tract # 128, but possible elevations in seven tracts (tracts # 127, 130, 131, 133, 140, 143, and 144).

- Stomach cancer -- no statistically significant elevations, but possible elevations in eight tracts (tracts # 122, 130, 137, 140, 144, 145, 147, and 148).

- Uterine cancer (females only) -- one statistically significant elevation in tract # 146. Six other tracts had possible elevations (tracts # 125, 127, 128, 137, 149, and 151).

- Brain and CNS cancer was not statistically significantly elevated in any tracts, but seven tracts had possible elevations (tract # 124, 127, 132, 138, 140, 144, and 149).

- Elevations in leukemia were not statistically significant in any tract, but seven tracts had possible elevations (tracts # 127, 128, 129, 143, 145, 146, and 149).

- Hodgkin's Disease was significantly elevated in one tract (# 138) and possibly elevated in four other tracts (tracts # 137, 144, 145, and 149).

- The All Other Cancer type category was elevated in 12 tracts (tract # 122, 125, 129, 130, 134, 135, 137, 140, 147, 148, 151, and 152).

  o Other cancer types (cancers of the cervix, esophagus, larynx, liver, testis, and thyroid) were elevated in fewer than five census tracts. The incidence of multiple myeloma was not elevated in any census tract.

**D. Differences in Cancer Incidence between Males and Females**

Overall, there were more cancers cases diagnosed among males than females (3,210 and 2,927, respectively) on the Upper Cape between 1986 and 1994. Statewide, the opposite is true, where more cases are diagnosed among females. However, for both males and females separately, the observed number of cases, overall, exceeded the number expected.

As previously mentioned, the four major cancer types accounted for most of the cancer diagnosed on both the Upper Cape and the state as a whole. Statewide, prostate cancer accounts for about 26% of total cancer in males. On the Upper Cape, it accounts for about 31% of total cancer. Statewide, colo-rectal cancer in males accounts for about 14 % of cancers, and on the Upper Cape it represents 15%. Lung cancer in males is about 17 % of total cancer in males statewide and about 16% on the Upper Cape.

Breast cancer and colo-rectal cancer in females represent about the same proportion of total cancer for the Upper Cape and the state (Breast: 31% vs. 32%, respectively, Colo-rectal: 15% vs. 14%, respectively). Lung cancer accounts for less than 12 % of total female cancer statewide, while on the Upper Cape it represents more than 14%.

In comparing which tracts had elevations for males or females separately with the tracts elevated for males and females combined, some important differences were noted.

The most notable difference between males and females is in lung cancer. Male lung cancer was statistically significantly elevated in only one census tract (tract # 144), with seven other tracts that were elevated but not statistically significant (tracts # 124, 125, 126, 132, 135, 148, and 150). Lung cancer among females, however, was elevated in 22 tracts (statistically significantly elevated in tracts # 126, 139, 140, and 148, non-significant elevations in tracts # 122, 124, 125, 127, 128, 129, 130, 132, 133, 135, 136, 137, 143, 144, 145, 146, 147, and 151).

Of the other cancer types, bladder cancer was the cancer type elevated, either statistically significantly or non-significantly, most frequently among males. Possible elevations in bladder cancer occurred among males in 12 tracts (tract # 125, 126, 131, 133, 134, 136, 137, 138, 144, 146, 148, and 151). In addition, elevations in the incidence of a number of cancers of the head, neck and upper gastrointestinal track also occurred primarily among males. Elevations in esophageal cancer (tract # 125 and 139), laryngeal cancer (tract # 145 and statistically significant elevation in tract # 148), and stomach cancer (tract # 144, and statistically significant elevations in tracts # 147, and 148) occurred only in males. Elevations in mouth and pharynx cancer were split more evenly between males and females, males having elevated rates in 6 tracts (tracts # 122, 124, 134, 137, 140, 149) and females in 5 tracts (tracts # 126, 133, 139, 144, and 149).

Melanoma was the next most frequently elevated cancer among males, after bladder cancer. The elevation among males in tract 132 was statistically significant and nine tracts had possible elevations (tracts # 122, 125, 127, 128, 133, 144, 147, 148, and 149) among males. Melanoma among females was statistically significantly elevated in two tracts (tracts # 135 and 143) and possibly elevated in four tracts (125, 130, 134, and 147).

Kidney cancer was more frequently elevated in males than in females. Kidney cancer was elevated among males in eight tracts (tracts # 122, 130, 134, 137, 138, 143, 147, and 148) and in five tracts among females (tracts # 126, 129, 136, 146, and 152). One elevation among males was significantly elevated (tract # 147) and three elevations among females were significantly elevated (tracts # 129, 136, and 146).

On the other hand, non-Hodgkin’s lymphoma was more frequently elevated in females than in males at the census tract level. Seven tracts had possible elevations among females (tracts # 122, 125, 130, 136, 137, 140 and 148), whereas four tracts had elevations among males (tracts # 135, 139, 143, and 147). One elevation was significant for each sex (tract # 125 for females and tract # 135 for males).

Two cancers that have been of special interest to community representatives on the Community Assistance Panel (CAP) are brain/CNS cancer and leukemia. Among males, four tracts were elevated for brain/CNS cancer (tracts # 124, 138, 140, and 149) with tracts # 138 and 149 statistically significant. Two tracts were elevated for brain/CNS cancer among females, but the tracts were different (tracts # 132 and 144) from where elevations were seen in males and neither was statistically significant.

Leukemia was elevated among males in four tracts, though none are statistically significant (tracts # 128, 143, 145, and 146). Among females, leukemia was elevated in three different (tracts # 129, 148, and 149) tracts. One elevation among females was statistically significant (tract # 129).

## IV. DISCUSSION

This descriptive analysis of cancer incidence data for the Upper Cape towns evaluated 23 specific cancer types, as well as total cancer incidence, for the Upper Cape as a whole, for each of the five towns, and for each of the 30 census tracts that composed the Upper Cape. Cancer incidence for all cancer types combined for the Upper Cape as a whole was statistically significantly elevated compared to the statewide experience. Cancer, however, is not one disease but a group of over 100 diseases, each with distinct etiologies and characteristics. Thus, it is more meaningful to evaluate patterns of specific cancer types.

The majority of cancers among Upper Cape residents, as is the case in the state and the nation, are lung, breast, prostate, and colo-rectal cancers. These four major cancers combined composed a slightly greater proportion of total number of cancers on the Upper Cape than was observed statewide. This difference was due to a greater proportion of prostate cancer and female lung cancer cases on the Upper Cape than among residents of Massachusetts as a whole.

When the five Upper Cape towns were combined, statistically significant elevations were seen for female breast cancer, colo-rectal cancer (among males and among both sexes combined), female lung cancer, and prostate cancer. In addition, statistically significant elevations were seen in melanoma (among males, among females, and among both sexes combined). No statistically significant elevations for the Upper Cape as a whole were seen in the other 18 specific cancer types evaluated in this report. Thus, the overall elevation in cancer for the Upper Cape as a whole is attributed primarily to these five cancer types: female breast cancer, colo-rectal cancer, female lung cancer, melanoma, and prostate.

Not surprisingly, because of the larger numbers and therefore more stable SIRs, about two-thirds of the statistically significant elevations at the census tract level (males and females combined) were among the four major cancer types - prostate cancer (9 census tracts), lung cancer (4 census tracts), breast cancer (3 census tracts), and colo-rectal cancer (3 census tracts). The other statistically significant elevations at the census tract level were elevations in 9 different cancer types (melanoma, uterus, ovary, kidney, larynx, Hodgkin's disease, pancreas, testis, liver), most of which have no known environmental risk factors, among 9 different census tracts.

For purposes of this report, BEHA also defined an "elevation" as that in which the SIR was greater than 115 or when 2 or more excess cases occurred when the observed number of cases was less than 5 (and therefore no SIR was calculated). The majority of these non-statistically significant elevations at the census tract level involved a cancer type in which a small excess (i.e., 1 or 2 cancers) occurred versus what was expected.

With the exception of one census tract (148), no census tract had more than two statistically significant elevations in any cancer type for males and females combined, for males, or for females. When examining the census tracts for elevations (i.e., either statistically significant or not, as defined in this report), the majority of cancer types for all census tracts were not elevated. About one-third of the census tracts had 8 to 11 cancer types elevated among both sexes combined, with the majority of these elevations consisting of 1 or 2 excess cases.

Some differences between the sexes were seen in cancer incidence patterns. Female lung cancer was elevated in over two-thirds of the census tracts (22 tracts), with 4 statistically significant elevations. Male lung cancer, on the other hand, was elevated in less than one-third of the census tracts (8 tracts), with one significant elevation among males at the census tract level. For bladder cancer, 12 census tracts had elevations among males, with 9 of these tracts having small excesses (i.e., 1 or 2 cases). No elevations were seen in bladder cancer among females. Melanoma was more often elevated at the census tract level among males (11 census tracts; one was statistically significant) than among females (6 census tracts; two were statistically significant). For the most part, other cancer types did not show as much difference between the sexes as those mentioned here.

When searching for geographic patterns of cancer incidence, it is important to keep in mind that these statistical results do not consider individual-level information, such as length of residence, previous residence, occupational exposures, medical history, and other possible risk factors. In addition, geographic patterns in cancer incidence must be examined in light of the fact that different types of cancer have different risk factors. For example, most of the statistically significant elevations observed at the census tract level for the Upper Cape were among cancer types with different known or suspected etiologies (i.e., lung, breast, colo-rectal, prostate, melanoma).

Earlier studies of cancer incidence on the Upper Cape that did examine length of residency (1, 9) have shown that cancer rates were elevated in long term residents. Therefore, it does not appear that the cancer experience of more recent Upper Cape residents were responsible for the observed elevated rates of cancer.

In general, the patterns of cancer incidence did not appear to readily suggest any clear environmental hypotheses. For example, elevations in female breast cancer were scattered throughout the Upper Cape. Also, nearly all census tracts had an elevation in either female lung cancer or prostate cancer. Colo-rectal cancer was elevated in 13 census tracts among females and 16 tracts among males. However, most of these elevations occurred in different census tracts among males versus among females.

The 1982-1990 Upper Cape Cod Cancer Incidence Review reported that three cancer types seemed to be elevated primarily near the MMR. These cancers were brain/CNS, cervical, and laryngeal cancer.

In the 1982-1990 report, cervical cancer was elevated in one tract abutting the MMR (tract 137). From 1986-1994, cervical cancer was again elevated in census tract 137 but also elevated in tracts 144, 146, and 150. All elevations consisted of 2 or 3 more cases observed than expected and none were statistically significant.

Cancer of the larynx was elevated during the 1982-1990 period in five tracts (males in tracts 130, 139, 140, and 144, and males and females combined in tract 145). During the 1986-1994 period, cancer of the larynx was elevated in 2 tracts (census tracts 145 and 148).

In the 1982-1990 report, four tracts were elevated for brain/CNS cancer (tracts 137, 138, 144, and 150 for males and females combined). In this review, a total of 7 census tracts had elevations (124, 138, 140, 144, and 149 for males and females combined). Thus, the geographic pattern for this cancer type was more scattered than in the previous review.

**A. Comparison with Massachusetts Cancer Registry Reports on Cancer Incidence**

The Massachusetts Cancer Registry (MCR) does not report or estimate cancer incidence at the census tract level. The MCR produces reports on cancer incidence at the town level and recently released a report on cancer incidence from for the period 1987-1994. The town level numbers in this review will differ from the numbers in the recent 1987-1994 MCR report for three reasons: differences in time period, differences in the validation of case addresses that can affect the numbers of observed cases, and differences in the number of age adjustment categories used to calculate the expected numbers of cancers.

The difference in the observed numbers has been discussed in the methods and results sections of this review. Environmental epidemiologic investigations, including those at the BEHA, routinely must geocode the addresses reported by the MCR and this process often requires validation of the address beyond that carried out by the MCR. As a result, residential addresses, which are the addresses that researchers wish to geocode, are sometimes found to be different from the address reported to the MCR because that address is often a mailing address. This can sometimes change the town that the case was attributed to by the MCR. Duplicate case reports also can come to the attention of the researcher during this process. Both of these activities, which are designed to provide a more valid research database, can result in a different number of observed cases than shown in MCR reports, and this was found to be true in this review (Tables 3, 4, 5, and 6).

The methodology used to calculate the expected numbers in this report was identical to that used by the MCR in their reports of cancer incidence, except for the number of age categories used. The MCR used 6 age categories, whereas the age adjustment calculations in this report used 10 age categories. Table 7 provides an example of this difference in age adjustment for total cancer among females.

Increasing the number of age groups from 6 to 10 allows for a more precise adjustment for the effect of age. In a general sense, increasing the number of age categories used in the age adjustment procedure can either increase or decrease the expected number of cancers, depending on the population distribution and the type of cancer under consideration. On Upper Cape Cod, a tighter control of the effect of age by increasing the number of age categories usually had the effect of increasing the number of expected cancers. This is because the Upper Cape population is, generally speaking, older than the state as a whole (see Table 7). For example, the MCR estimated that 2164.2 females on the Upper Cape would have been expected to be diagnosed with some sort of cancer between 1987 and 1994, whereas BEHA estimated approximately 2383 cancer diagnoses. Using the address-validated observed numbers, the larger expected numbers in the BEHA calculation resulted in a smaller SIR for total cancer among females (BEHA SIR = 110, MCR SIR = 112 for 1987-1994 period).

Table 8 provides the comparison of the observed numbers, expected numbers and SIRs for total cancer, lung cancer and female breast cancer. Similar to the SIR for total cancer, the SIR for lung cancer as calculated by BEHA (115) is smaller than the SIR calculated by the MCR (118), because of differences in the age adjustment categories. The difference in the number of observed cancers further decreased the BEHA SIR (SIR = 113). Female breast cancer was an exception to this trend as the expected number of cancers (728.2), as calculated by BEHA, was actually lower than the MCR total (752.8). This is because the MCR age categories include a large age group of ages 45-64, a grouping that contained a great deal of age variation in breast cancer incidence.

It should be noted that the data provided by the MCR in its reports are intended as surveillance data. Although they undergo rigorous quality assurance, it is the individual researcher who has the responsibility of final data quality and of statistical analyses that may be more exact that those carried out by the MCR for its surveillance system. For these reasons, the statistics provided by researchers may be understandably different and more precise than those presented in surveillance reports.

**B. Sensitivity Analyses - Changes in 1986-1994 SIRs**

As explained earlier, when researchers geocode addresses for their study area, they may change some addresses that are mailing addresses to the appropriate residential address. However, if SIRs are subsequently estimated, the observed number of cases would be based upon validated addresses but the expected number would not. This is because the expected number is partly based upon the cases diagnosed elsewhere in the state and their addresses will not have been checked. While these addresses only have to be correctly identified as residents of non-Upper Cape Cod Massachusetts' towns and so a precise address is not as important, there may be some situations where not checking these addresses could theoretically have an affect on the resultant SIR value. For example, some cases living in Barnstable may have a mailing address reported to the MCR as Yarmouth. Similarly, in this report we saw that some cases living in Wareham were reported to the MCR as Bourne cases because that was their post office location. The technical advisors to the ATSDR Community Assistance Panel (CAP), therefore, suggested a series of sensitivity analyses to explore the effect of address validation on the resulting SIRs.

A discussion of the methodology and results, as well as tables containing the observed and expected numbers of cancers and the 95% CI for each town and cancer type are available in Appendix E. The resulting total cancer SIRs are presented in Table 9. In order to assess the effect of only validating addresses in the study population, the expected numbers of cancers were adjusted by a constant reflecting the change in the observed numbers of cancers due to correcting for duplicate case reports and misclassified addresses. The adjustment factors were based on the change in observed numbers seen for each Upper Cape town. Although the state data used to generate the expected numbers of cancers may still contain misclassified cases, we do not know whether the rest of the state experiences these kind of misclassifications at the same rate as the Upper Cape. However, it is known that certain areas of the state, such as Bourne/Wareham share postal zip codes. It can, therefore, be expected that different areas will have different rates of misclassified addresses.

The affect on the SIR due to the adjustment in the expected number of cancers varied depending on the cancer type under scrutiny and depending on which adjustment factor was used. Although the unadjusted SIRs were frequently smaller than the adjusted SIRs, some town-specific adjustments resulted in an SIR that was lower than the unadjusted SIR (for example, Mashpee data in Table 9). Furthermore, the quantitative fluctuations in the SIRs due to adjustment for address validation did not vary enough to qualitatively alter the basic findings. The analyses suggest that the small changes in the SIRs do not alter the basic pattern of elevations in cancer incidence on the Upper Cape, either by type of cancer or by geographic region.

Most importantly, without knowledge of how the proportion of duplicate reports and address corrections vary for each town across the state, it is not possible to identify the appropriate adjustment factor. Furthermore, the analyses show that an adjustment effect at the town level may not be predictive of its effect at the census tract level. It would seem advisable to correctly validate addresses within the study area so that correct geographic relationships between the location of a residence and some area of potential environmental exposure can be properly assessed. At the same time, it should be understood that the statistics calculated from the available incidence data are estimates and cannot be considered precise reflections of the true incidence rate for the reasons stated here and elsewhere in the discussion section.

### C. Limitations of Upper Cape Cod Cancer Incidence Review, 1986-1994

The Upper Cape Cod Cancer Incidence Review has two major limitations. The first is that this review was not an analytic epidemiologic investigation (e.g., a case-control study with information on individual exposures and other cancer risk factors), so our ability to draw inferences from the data are limited. The use of SIRs to identify which geographic areas have a higher, lower, or similar incidence rate than the state is a useful tool to generate hypotheses about factors that could be further investigated as possible causal factors for the observed incidence pattern. However, hypotheses about the causes of cancer cannot be tested using SIRs, because we do not know whether the people who were diagnosed with cancer were actually exposed to a particular factor.

The second major limitation of this review relates to the use of residence at the time of diagnosis. SIRs provide a picture of the geographic distribution of cancer incidence only at the time of diagnosis. Most cancers have a long latency period between the occurrence of the cancer-causing insult (or insults) to the cellular tissue and the time that their cancer is clinically diagnosable (usually a range of 10-30 years). Therefore, the geographic pattern of SIRs that are observed in this review may not reflect the pattern of incidence at the time the cancers were initiated. For this additional reason, SIRs cannot be used as evidence of some causal relationship but can be used to determine whether further study or other public health activities may be warranted.

Another aspect of this cancer incidence review regards the precision of the estimates of incidence. This is not so much a limitation of the work but a distinctive feature of it that should be recognized. Throughout the document, there has been discussion of the (1) how estimates of population must be used in the calculation of SIRs because true population values don’t exist, (2) how different researchers use different refinements of the methods depending upon their research goals, and (3) how small numbers of cases and population can affect calculations because of statistically unstable rates. Each of these factors can lead to imprecise estimates of incidence ratios (i.e., SIRs). This is evidenced by the wide confidence intervals shown in the tables. This imprecision does not invalidate the data but it does preclude their strict interpretation. In practical terms, this means that, for example, the observation that an elevated SIR value for a cancer type in one census tract is higher than that in another tract is not necessarily important or even meaningful. What is meaningful is whether the incidence appears elevated and whether patterns in elevations are noted.

## V. CONCLUSIONS

This report contains a descriptive analysis of cancer incidence data from 1986-1994 for Upper Cape Cod. Conclusions from the analysis include the following:

1. The cancer type that was most often elevated at the census tract level, as defined in this report (i.e., statistically significant elevation; SIR $ 115; or at least two excess cases when the observed number of cases was less than 5), was female lung cancer. An elevation was seen in 22 of 30 census tracts (with 4 statistically significant elevations) of Upper Cape Cod.
2. The cancer type that was most often statistically significantly elevated at the census tract level was prostate cancer (9 statistically significant elevations). A total of 20 census tracts had elevations in prostate cancer. Furthermore, the proportion of total cancer attributable to prostate cancer was greater on the Upper Cape than statewide.

3. Melanoma was also frequently found to be elevated in Upper Cape census tracts. It was elevated in a total of 16 census tracts and was more often elevated among males (11 census tracts) than among females (6 census tracts). Melanoma also represented a higher proportion of total cancer among residents of Upper Cape Cod than among residents of Massachusetts as a whole.
4. Female breast cancer was elevated in 13 census tracts, with a geographic distribution scattered throughout the Upper Cape.
5. Most cancer types for the Upper Cape as a whole and its 30 census tracts were not elevated, as defined in this report.
6. No particular type of cancer seems to account for the Upper Cape's overall elevated rates, but a number of generally etiologically unrelated cancers contribute to the elevation. Specifically, these cancer types are female breast cancer, colo-rectal cancer, female lung cancer, melanoma, and prostate cancer, which accounted for 62 percent of all cancers diagnosed among Upper Cape Cod residents.
7. The incidence of total cancer among males and females combined was 11 percent higher than expected after adjusting for age differences. Among males it was 12 percent higher and among females it was 10 percent higher. These elevations were each statistically significant.
8. No consistent pattern of elevations was observed by sex. For example, although lung cancer was more often elevated among females (22 tracts) than among males (8 tracts), bladder cancer was elevated only among males (12 tracts). Colo-rectal cancer was elevated among males (16 census tracts) and among females (13 census tracts), but most of these elevations occurred in different tracts among males versus those among females.

## VI. RECOMMENDATIONS

1. Follow-up of elevated lung cancer incidence among females.

a. The feasibility of conducting an epidemiologic study of female lung cancer and possible association with the Upper Cape environment (e.g., Canal Electric plant) should be undertaken. The feasibility assessment would include identifying the vital status of cases, availability of air emissions data for different air sources, evaluating existing air modeling results, and the appropriateness of air monitoring.

b. Evaluation of available smoking data.

- i. Survey results from efforts such as the MDPH Behaviorial Risk Factor Survey should be reviewed. These may provide insight into the prevalence of smoking among females on the Upper Cape as compared to the prevalence in other areas, and thus contribute to a greater understanding of the plausibility of smoking as an explanation for the elevated lung cancer rates.
- ii. Analyses of smoking status of female lung cancer case, as reported to the Massachusetts Cancer Registry, should be carried out to determine if the proportion of smokers on the Upper Cape is different from the proportion statewide.

2. The Bureau of Environmental Health Assessment will provide this report to the Bureau of Family and Community Health, Office of Cancer Control, to determine appropriate primary and secondary prevention/intervention strategies, including the need for public health education efforts.

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## VII. REFERENCES

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## I. APPENDICES

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| **APPENDIX A** | 1990 Population by Census Tract, Sex and Age |
| **APPENDIX B** | Summary SIRs by Census Tract and Sex, Grouped by Cancer Type |
| **APPENDIX C** | Observed and Expected Numbers of Cases, SIRs, and Confidence Intervals by Cancer Type and Sex for Upper Cape Cod, Grouped by Town |
| **APPENDIX D** | Observed and Expected Numbers of Cases, SIRs, and Confidence Intervals by Cancer Type and Sex for Upper Cape Cod, Grouped by Census Tract |
| **APPENDIX E** | Sensitivity Analyses: Observed and Expected Numbers, Standardized Incidence Ratios and 95% Confidence Intervals for Total Cancer |

**PLEASE NOTE:**

The Massachusetts Department of Public Health, Bureau of Environmental Health Assessment was unable to make Appendix A, Appendix D and Appendix E available via the Internet.

**Please call (617) 624-5757 to request photocopies of the original documents.**

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**PLEASE NOTE:**

The Massachusetts Department of Public Health, Bureau of Environmental Health Assessment was unable to make the following figures available via the Internet.

**FIGURES**



All accompanying maps contained in Volume I

**Please call (617) 624-5757 to request photocopies of the original documents.**